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The effects of the quality and quantity of education on income inequality

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Abstract

High levels of income inequality characterize both developed and developing countries. This paper focuses on how the quality of education, measured by international, standardized test scores, and the quantity of education, measured by the average years of school attainment, affect the distribution of income. Overall, both greater educational achievement and educational attainment reduce income inequality. The marginal effect, however, is stronger for increases the educational attainment when considering their interactive effects. This result is robust, and strengthened, when the focus is on only developing countries, and to the inclusion of additional factors attributed to the growth of inequality such as globalization, technological progress, the quality of institutions and educational spending. Considering only the quantity of education misses other important elements of education that contribute to explaining the dynamics of income inequality.

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1 Introduction

Persistently high income inequality is a characteristic of many countries across the development spectrum. Explaining the growth of income inequality over recent decades has largely focused on globalization, skill-biased technological change, and institutional quality, such as corruption and rule of law. The focus of this paper is on the relationship between both educational attainment and educational achievement and income inequality. Both dimensions of education are shown to be negatively related to income inequality and are robust to multiple empirical specifications and the inclusion of control variables. Moreover, increasing the educational attainment has a stronger marginal effect when compared to improving the educational achievement. This is in contrast to recent studies that find the quality of education (achievement) is more closely related to economic growth than the quantity of education (attainment).

While the focus of this paper is on income inequality, distinguishing between the effects of the quantity and quality of education is more common in the economic growth literature. The empirical link between the quantity of education and economic growth is largely positive and significant when using quantitative measures such as the average years of education (Barro 1991, 1997, Mankiw, Romer, and Weil 1992, and Sala-i-Martin *et al.* 2004, among others). Yet, measures of educational attainment may not fully capture what is actually being learned while in (formal) schooling. An additional year of schooling in one country may differ significantly in terms of quality when compared to another country. Moreover, the quantity of formal education may miss factors that contribute to knowledge attained outside the classroom. Measures of educational quality attempts to fill this gap by focusing on student achievement tests that are internationally comparable (Angrist *et al.* 2013). There is empirical evidence suggesting that the quality of education is not only another important factor for economic growth but may have stronger quantitative affects (Hanushek and Kimko 2000, Pritchett 2001, Hanushek and Woessman 2008, 2009, 2012, among others).

With regards to income inequality, De Gregorio and Lee (2002) find that greater educational attainment is associated with a more equal distribution of income between 1965 and 1990. Castello-Climent and Domenech (2014) extend the database to 2010 finding a negative relationship between the supply of skills (educational attainment) and income inequality. Dabla-Norris *et al.* (2015), however, finds no statistically significant relationship between income inequality and education levels and the evidence is mixed in Coady and Dizioli (2017) who find it dependent on the empirical specification.

The theoretical connection between educational attainment and education quality and income inequality is also mixed. For example, Knight and Sabot (1983) argue that increased human capital accumulation initially increases the relative size of those with more, or improved, education resulting in greater inequality, but the additional supply of educated workers decreases their wage premium leaving the total effect ambiguous. Beyond the development economics literature, Datta and Mohtadi (2006) and Hall (2017) link education to inequality in models of international trade and endogenous growth. In both cases the transfer of new technologies between countries will increase inequality but the magnitude is offset by level of human capital within the country. Specifically, Hall (2017) finds countries with a low quality or quantity of education will see a rise in inequality and decrease in inequality if the education levels are stronger in the process of economic development. Datta

and Mohtadi (2006) label this the "absorptive capacity" of the country based on their levels of human capital.

This paper extends the empirical literature on education and inequality by focusing on both the quantity of education as measured by the average years of school attainment and the quality of education as measured by student achievement. Data for the quantity of education is the average years of school attainment for persons aged 15 or older from Barro and Lee (2013) and the average adjusted test score from the World Bank is used to capture the quality of education. Using a large set of developing and developed countries between 1980 and 2010, I find both the quantity and quality of education have an equalizing effect on income inequality. For the majority of empirical specifications, increasing educational attainment reduces inequality by a greater amount when compared to improving educational achievement. This finding is robust to multiple measures of income inequality and other common explanatory variables such as globalization, technological progress, and institutional quality. Multiple econometric approaches are used including both static panel data models and dynamic models with the lagged dependent variable used as an instrument.

Both the educational achievement and educational attainment have negative, significant direct effects on income inequality and they are also dependent on one another. This is captured by the interaction between quality and quantity of education. When the quantity of education is sufficiently low, improvements in educational achievement may actually increase income inequality. The better schooling outcomes are captured by fewer individuals which serve to widen the income gap. As educational attainment increases in a country, improvements in the quality of education serve to reduce inequality. In 2010, the results show that improvements in the quality of education results in a decrease in income inequality for 96 of 140 countries and an increase in the remaining 44 countries with a sufficiently low quantity of education. The quality of education also affects the impact of increases in educational attainment. As of 2010, all countries with available data had an average test score that was sufficiently high such that increasing the quantity of education reduces income inequality.

The results are strengthened when considering only developing countries and are robust to a number of control variables. The results hold when controlling for measures of globalization such as trade openness, tariff level, and remittance inflow; measures of technological change such as the share of manufactured exports considered high-tech; measures of institutional quality such as corruption, rule of law and regulatory quality; and meaures of educational spending. The rates of educational completion are also considered as a robustness check.

Section 2, first, presents the econometric approach, data sources, and baseline results. The results are then applied to countries with available data in 2010. In addition, robustness tests include a focus on developing countries only and the inclusion of control variables. Section 3 concludes.

2 Empirical Analysis

2.1 Data and Econometric Approach

The paper considers a large set of developed and developing countries over a 30-year period from 1980 to 2010. 5-year non-overlapping periods were used when possible to smooth out year-to-year fluctuations. For example, "1990" represents the average from 1988-1992 and

"1995" represents 1993-1997 for annually reported data series.

Income inequality is measured as the Gini coefficient. The World Bank and the United Nations offer data during this time period for a large set of countries. For the 2008-2012 time period average, the "2010" period, there were at total of 117 countries with at least one observation using the United Nations World Income Inequality Database (93 developing countries) and 110 such countries based on the World Bank (87 developing countries). The World Bank Gini coefficient averages 38.6 for all countries and 40.4 for only developing countries. Qualitatively the empirical results are consistent with only small quantitative changes utilizing the two measures. The results of this paper are based on the World Bank measurement of income inequality but qualitatively do not change using the United Nations data for inequality.

The quality and quantity of education are inherently difficult to consistently measure across a large set of countries over an extended time frame. The quality of education is measured by the *Averaged Adjusted Test Score* provided by the World Bank. This test score is standardized over time, across subjects, across schooling levels and international/regional assessments (Angrist *et al.* 2013).[1] The average score is 48.6 with a minimum of 33.2 (Qatar) and a maximum of 58.3 (Korea). The average years of education for persons aged 15 and over is the measure for the quantity of education from Barro and Lee (2013). This data is compiled over 5-year time intervals based on census and survey information from UNESCO, Eurostat and other sources. The 2010 average for all countries is 8.4 and ranges from 1.9 (Niger) to 13.2 (USA). Table 1 summarizes the data for the "2010" time period (average of available data between 2008 and 2012) for income inequality as measured by the World Bank, the quality of education and the quantity of education.

The first set of econometric tests include the lagged Gini coefficient as a dependent variable as an instrument creating a dynamic panel model. This model is appropriate if there are slowly-changing factors, such as institutional or cultural factors, that lead income inequality to display persistence over time. Coady and Dizioli (2017) also accounts for the limited within-country variation between time periods. Mahesh (2016) uses a similar econometric approach when using income inequality as the dependent variable. Equation (1) includes the quality or quantity of education individually and equation (2) includes both the quality and quantity of education with the interaction term between the quality and quantity of education.

[1]The long definition is defined as: "A test score that has been standardized over time, across subjects, across schooling levels, and across various international and regional assessments. It is calculated by creating a ratio between U.S. scores averaged across subjects and over schooling level on all international tests (such as PISA and TIMSS) to average scores averaged across subjects and over schooling levels on the U.S. National Assessment of Educational Progress (NAEP) approximated to the nearest 5-year time step from 1965-2010. All raw international scores are averaged across subjects and over school levels and approximated to the nearest 5-year interval, averaged across tests, and then multiplied by this ratio. This makes these adjusted scores comparable over time, across countries and across international tests. Test scores from countries which only participate in regional assessments are included in the above transformation after being averaged across subjects and over schooling levels and then multiplied by a ratio comparing average scores across subjects and schooling levels in a given regional test and average scores across subjects and schooling levels on an international assessment for all doubloon countries - countries which participate in the same regional assessment and an international test. This makes adjusted test scores comparable over time, across subjects, across schooling levels, over countries and over all assessments (Angrist *et al.* 2013)."

Table 1: Summary Statistics, 2008-2012, All Countries

	Gini Coefficient World Bank	Educational Achievement Adjusted Test Scores	Educational Attainment Average Years of Education
Average	38.644	48.618	8.437
Minimum	24.780	33.212	1.877
Maximum	63.200	58.321	13.183
Observations	110	57	146

Table 1: The Gini coefficient is from the World Bank. The average years of education for persons aged 15 and over is for 2010 and from Barro and Lee (2013). The measures of income inequality and the averaged adjusted test scores are the average of all available data for each country between 2008 and 2012.

$$GINI_{i,t} = \beta_0 + \beta_1 GINI_{i,t-1} + \beta_2 GDPpc_{i,t} + \beta_3 GDPpc_{i,t}^2 + \beta_4 EDU_{i,t} + \gamma_{i,t} + \epsilon_{i,t}; \quad (1)$$

and

$$\begin{aligned} GINI_{i,t} = \; & \beta_0 + \beta_1 GINI_{i,t-1} + \beta_2 GDPpc_{i,t} + \beta_3 GDPpc_{i,t}^2 + \beta_4 SCORE_{i,t} \\ & + \beta_5 YEARS_{i,t} + \beta_6 SCORE * YEARS_{i,t} + \gamma_{i,t} + \epsilon_{i,t}; . \end{aligned} \quad (2)$$

Equations (3) and (4) represents the second set of econometric tests that directly investigates the empirical relationship between income inequality and the quality and quantity of education both with and without the interaction term.

$$GINI_{i,t} = \beta_0 + \beta_1 GDPpc_{i,t} + \beta_2 GDPpc_{i,t}^2 + \beta_3 EDU_{i,t} + \gamma_{i,t} + \epsilon_{i,t}; \quad (3)$$

and

$$\begin{aligned} GINI_{i,t} = \; & \beta_0 + \beta_1 GDPpc_{i,t} + \beta_2 GDPpc_{i,t}^2 + \beta_3 SCORE_{i,t} + \beta_4 YEARS_{i,t} \\ & + \beta_5 SCORE * YEARS_{i,t} + \gamma_{i,t} + \epsilon_{i,t} \end{aligned} \quad (4)$$

where $GINI$ is the natural log of the Gini coefficient for country i in time t; $GINI_{t-1}$ is the lagged Gini coefficient; $GDPpc$ is the natural log of the real GDP per capita; EDU is a measure of the quality or quantity of education; $SCORE$ is the natural log of the average adjusted test score (quality of education); and $YEARS$ is the natural log of the average years of education (quantity of education). $\gamma_{i,t}$ is the between country error term and $\epsilon_{i,t}$ is the within country error term. A random effects model is used throughout the paper which is appropriate given the limited country-specific complete observations over the six time periods. The real GDP per capita and its squared value are from the World Bank and control for the Kuznet's Curve - the inverted U-shape dynamic of inequality over the course of development based on Kuznets (1955) and Barro (2000). Other measures are used as control variables to reflect globalization, technological change, institutional quality, and educational spending as a robustness check.

2.2 Empirical Results

Table 2 contains the baseline results relating the quality and quantity of education and income inequality as measured by the World Bank for all available countries. Columns (1) and (2) are based on equation (1), including the lagged Gini coefficient, the measures of education individually and controlling for the Kuznet's curve. Column (3) is based on equation (2) with the interaction between the quality and quantity of education. Columns (4) and (5) are the results based on (3) which directly tests the relationship between income inequality and the measures of education. Finally, column (6) includes the interaction term. All variables are measured in natural log form. The Kuznet's curve hypothesis is affirmed in each of the specifications indicated by consistent positive values for the GDP per capita and negative values for its squared value.

Table 2: Baseline Results, All Countries

	(1)	(2)	(3)	(4)	(5)	(6)
$Constant$	0.448 (1.14)	0.221 (0.77)	-1.441** (-2.39)	3.458*** (5.35)	2.091*** (5.73)	0.418 (0.47)
$Gini_{t-1}$	0.782*** (18.20)	0.607*** (16.60)	0.649*** (14.60)			
$GDPpc$	0.164** (2.03)	0.322*** (4.43)	0.214** (2.24)	0.210 (1.48)	0.474*** (5.26)	0.310** (2.12)
$GDPpc^2$	-0.009** (-2.01)	-0.019*** (-4.57)	-0.016** (-2.17)	-0.015* (-1.89)	-0.028*** (-5.33)	-0.019*** (-2.31)
$SCORE$	-0.100* (-1.74)		0.573*** (3.26)	-0.118* (-1.72)		0.696*** (3.04)
$YEARS$		-0.051* (-1.84)	0.945*** (3.02)		-0.171*** (-5.74)	1.106*** (2.65)
$Interaction$			-0.299*** (-3.36)			-0.367*** (-3.16)
Observations R-squared	145 0.833	256 0.776	137 0.873	205 0.283	424 0.221	192 0.451

Table 2: *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level. The dependent variable is the Gini coefficient obtained from the World Bank.

Columns (1), (2), (4) and (5) from Table 2 include only the measure of educational achievement ($SCORE$) or the measure of educational attainment ($YEARS$) in isolation with and without the lagged Gini coefficient and controlling only for the Kuznet's curve. The direct marginal effect of the quality and quantity of education is negative and significant, indicating a higher quality or quantity of education is associated with lower income inequality. When the lagged Gini coefficient is included, the quality of education has stronger, negative affect on inequality. Marginal effect for the quality of education is -0.100 (column 1) while the marginal effect of the quantity of education is -0.051 (column 2). The quantity of education has a stronger marginal effect when the lagged Gini coefficient is not included. Without the

lagged Gini coefficient, the marginal effects of the quality of education is -0.0118 (column 4) compared to the marginal effect of -0.171 (column 5) for the quantity of education.

The signs of the direct coefficients on the measures of education are reversed when the interaction term is included and the interaction term is negative. The strong significance of the coefficients indicates that marginal effect of the quality of education depends on the quantity of education and vice versa. Columns (3) and (6) include the interaction term. Based on column (3) the marginal effect of the quality of education is given by $0.573 - 0.299 * YEARS$. The overall average years of education for the entire dataset is 6.863 years with a minimum of 0.234 and a maximum of 13.183. Using the natural log of these values, the marginal effect a one percent increase in the educational achievement ranges from a reduction in inequality of 0.198 percent to an increase of 1.007 percent with a decrease of 0.003 percent for the average country. Without the lagged Gini coefficient, the marginal effect of the quality of education is $0.696 - 0.367 * YEARS$. The range of marginal effects is between -0.250 and 1.229 percent with an average of -0.011 percent depending on the average years of education in a specific country.

An implication from the results in columns (3) and (6) in Table 2 is the existence of thresholds in which higher educational test scores may increase income inequality. Based on column (3) the implied threshold is 6.8 years of education and based on column (6) the threshold is 6.7 years. For those countries with a quantity of education below the threshold, greater educational achievement benefits relatively fewer individuals and the result is an increase in income inequality. In 2010, 44 of the 140 countries in the dataset fall below this threshold which means higher achievement contributes to greater inequality given the low quantity of education. Table 3 lists the 44 countries in which the average years of education is below 6.7 as of 2010 by region.

Based on columns (3) and (6) the marginal effect of the quantity of education is given by $0.945 - 0.299 * SCORE$ with the lagged Gini coefficient and $1.106 - 0.367 * SCORE$ without. The direct coefficients and the interaction terms are statistically significant meaning increasing educational attainment reduces inequality by a greater amount when the quality of education is high. For the entire dataset, the quality of education ranges from an adjusted test score of 13.89 to 74.27 with an average of 45.563. With the lagged Gini coefficient, the marginal effect of a one percent increase in the average years of education ranges from -0.343 to 0.158 with an average of -0.197. Without the lagged Gini coefficient, the range is between-0.475 and 0.140 with an average of -0.296 based on the value of the adjusted test score. As with the quality of education, it is possible that increasing the average years of education may increase income inequality if the quality of the education is sufficiently low. The threshold adjusted test score is 23.583 with the lagged Gini and 20.361 without the lagged Gini. Between 2008 and 2012, 55 countries in the dataset with at least one observation on the average adjusted test score and none of those countries had an average test score below the threshold. This means that, as of the latest data observation, increasing the quantity of education unambiguously reduces income inequality.

2.3 Quality vs. Quantity of Education in 2010

When the quality and quantity of education are interacted, the results are statistically significant indicating the marginal effects of one measurement of education is dependent on

Table 3: Educational Attainment - 2010

Region	Country (Average Years of Education)
East Asia & the Pacific	Papua New Guinea (4.26), Cambodia (4.72), Myanmar (4.85), Laos (5.02)
Latin America & the Caribbean	Guatemala (4.57), Haiti (5.11), Honduras (6.19), Nicaragua (6.61)
Middle East & North Africa	Yemen (3.68), Morocco (4.96), Kuwait (6.34), Algeria (6.68), Syria (6.70)
South Asia	Afghanistan (3.85), Nepal (4.23), Pakistan (5.02), Bangladesh (5.91), Maldives (6.02), India (6.24)
Sub-Saharan Africa	Niger (1.88), Mozambique (1.93), Mali (1.97), Senegal (2.74), Sudan (3.21), Burundi (3.35), Dem. Rep. of Congo (3.66), Cent. Afr. Republic (3.76), Gambia (3.77), Liberia (4.2), Sierra Leone (4.23), Rwanda (4.36), Benin (4.43), Mauritania (4.53), Cote d'Ivoire (4.65), Malawi (4.81), Swaziland (5.06), Togo (5.49), Uganda (5.7), Tanzania (5.81), Lesotho (5.85), Congo (5.94), Kenya (6.14), Cameroon (6.15), Namibia (6.17)

Table 3: Countries with an average years of school attainment for the population aged 15 and over less than 6.7 years from Barro and Lee (2013).

the other. Table 4 summarizes the marginal effects of the quality of education based the minimum, maximum and average years of education as well as the marginal effects of the quantity of education based on values of the average adjusted test score during the 2010 dataset. The specific values for the minimum, maximum and average for the educational variables are found in Table 1.

On average, the marginal effects of the quantity of education are significantly stronger than those of the quality of education both with and without the lagged Gini coefficient when incorporating the interaction term. For example, a one percent increase in educational attainment reduces inequality by 0.216 percent with the lagged Gini coefficient included and 0.319 percent without the lag for a country with the average quality of education. This is stronger than the marginal effect of 0.065 and 0.087 for the quality of education. To reduce inequality for the average country, attention should be prioritized to increasing average school attainment. However, the marginal effects of increasing the quality of education could be stronger if the country has a sufficiently high quantity of education and a relatively low quality of education.

In the 2010 time period, 55 countries had data for both quality and quantity of education. Figure 1 plots the quality and quantity of education for each of the 55 countries. The straight lines compare the marginal effects of increasing the quality versus the quantity of education. The solid line with the solid dots is based off the regression results without the lagged Gini coefficient and the solid line with the empty dots is based off results with the lagged Gini. For any country above and to the left of the solid lines indicates that improving educational

Table 4: Summary of Marginal Effects, 2010

	Quality of Education		Quantity of Education	
	Lag	No Lag	Lag	No Lag
Average	-0.065	-0.087	-0.216	-0.319
Minimum	0.385	0.465	-0.102	-0.180
Maximum	-0.198	-0.250	-0.271	-0.386

Table 4: The marginal effects of the quality of education are based on the minimum, maximum and average years of school attainment from the population aged 15 and over from Barro and Lee (2013) in 2010. Those values are 1.877, 13.183 and 8.437 respectively. The marginal effects of the quantity of education are based on the minimum, maximum and average adjusted test score from the World Bank. Those values are 33.212, 58.321 and 48.618 respectively.

attainment will have a stronger equalizing effect compared to increasing the educational achievement.

All of the countries in 2010, except one, has a combination of educational achievement and education attainment in which the marginal effect of the attainment reduces income inequality by a greater magnitude. This does not suggest improving educational achievement does not reduce inequality, simply that inequality is reduced by a greater amount for an equal percentage increase in educational attainment. Only in Kyrgyzstan does improving the educational achievement reduce inequality by a greater magnitude compared to increasing the average years of school attainment when using the results without the lagged Gini coefficient. In 2010, Kyrgyzstan a relatively high level of school attainment (10.71 years) and relatively low level of achievement (average adjusted test score of 34.74). Identical analyses were conducted for 1980, 1985, 1990, 1995, 2000 and 2005 and the results were very similar. For nearly every observation, the marginal effect is stronger for the quantity of education. These full results are available upon request.

2.4 Robustness Checks

The robustness check is two-fold. One point of interest is whether the marginal effects of the educational achievement and educational attainment on income inequality differ when only focused on the developing countries in the sample; and the second is focused on the inclusion of other variables that contribute to income inequality. Globalization, for example, is linked to changes in inequality. The classic link between trade and inequality is based on comparative advantage where countries specialize in those industries in which they are relatively more competitive whether that be high or low skill-intensive industries. Technological advances are another contributor to inequality. Technological progress increases the demand for skilled labor and replaces some unskilled labor with automation. Greater demand for skilled workers serves to increase inequality while this force is counteracted by a growth in the quality or quantity of human capital through education. Another potential force is the institutional quality within a country. Corruption, rule of law, regulatory quality and overall institutional quality affects the distribution of income with a country. Government spending on education is also included as an additional control variable.

Including each potential driving factor is beyond the scope of the paper. However, once

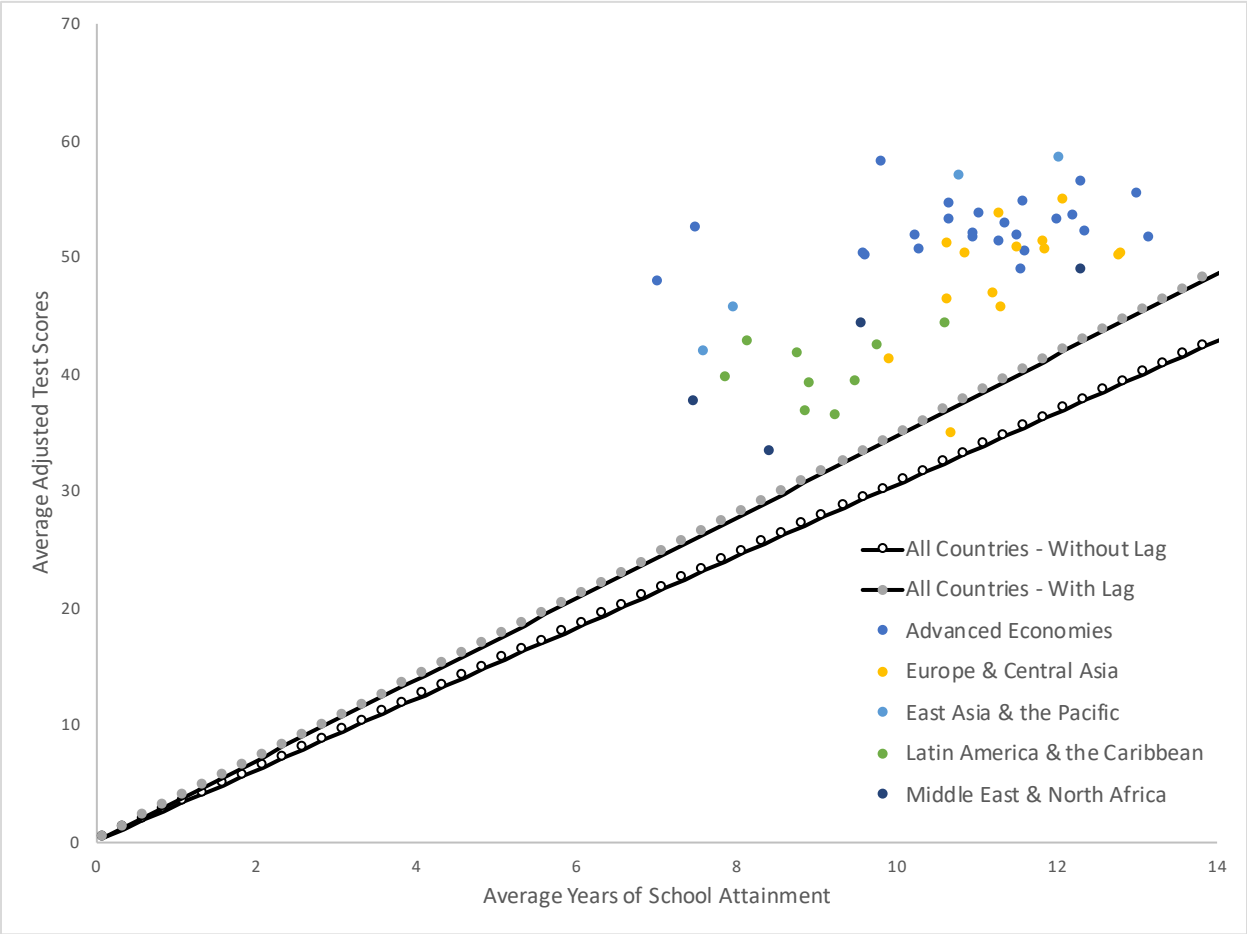

Figure 1: The marginal effect of the quantity of education is stronger compared to the quality of education if the country is located above and to the left of the solid lines. The solid lines are calculated based on the regression results with and without the lagged Gini coefficient. 55 countries have data for both the quality and quantity of education in the 2010 time period.

controlling for measures of globalization, technological progress, institutional quality or education spending, do the effects of the quality and quantity of education, including their interaction, change in a substantial way? To capture the extent of globalization for each country, *Openness* - export plus imports as a share of GDP in current US dollars from the World Bank Development Indicators is included. The results are also robust to other measures of globalization such as the inclusion of $Tariffs$ and *Remittances*. To measure technological progress, the share of *High-Tech Exports* as a share of manufactured exports from the World Bank Development Indicators is included. For institutional quality, the results using *Corruption* from the International Country Risk Guide is presented. The results are also robust to other measures of corruption, such as one from the Worldwide Governance Indicators, the *Rule of Law* from the Worldwide Governance Indicators, and *Quality Institutions* which includes corruption, law and order and bureaucracy quality from the International Country Risk Guide. Finally, *Public Expenditure on Education* as a share of GDP is included to control for government involvement in education so the effects of the quality and the quantity of education are isolated.

Table 5 compares the baseline marginal effects of both the quality and quantity of education without the lagged Gini coefficient, but including the interaction term, to a model in which only developing countries are considered and models with different control variables individually and taken together. The full regression results are suppressed for clarity. Using each of the control variables, the marginal effect of the quantity of education is stronger than that of the quality of education. In other words, increasing educational attainment has a more equalizing effect for the average country compared to improving average test scores. Also interesting from Table 5 is how the marginal effects of education become stronger with the inclusion of the control variables in nearly each of the cases. The importance of the quality and quantity of education is robust to other driving factors of income inequality and the focus on developing countries.

In 2010, the average years of school attainment for the population aged 15 and older from Barro and Lee (2013) was 8.437 years and the average adjusted test score was 48.618. The natural log of these averages are used in Table 5.

Table 5: Summary of Marginal Effects for Developing Countries Only and with Controls

	Quality of Education Marginal Effect	Quantity of Education Marginal Effect
Baseline	-0.087	-0.319
Developing Countries	-0.143	-0.409
Openness	-0.165	-0.333
High-Tech Exports	-0.084	-0.369
Corruption	-0.175	-0.444
EDU Spending	-0.087	-0.296
All Controls	-0.136	-0.309

Table 5: The marginal effects of the quality of education are based on the average years of school attainment from the population aged 15 and over from Barro and Lee (2013) in 2010 which is 8.437 years. The marginal effects of the quantity of education are based on the average adjusted test score from the World Bank which is 48.618. The results with the control factors are based on all available country data.

There is a significant drop in the number of observations when only considering developing countries - primarily due to data regarding the average adjusted test scores - the results are qualitatively similar to the full sample and the quantitative marginal effects are stronger when only developing countries are considered. Improvements in achievement or increases in attainment reduce inequality relatively more in developing countries compared to developed countries. The marginal effects of educational achievement and attainment are amplified both directly and when their interaction is included when focusing on developing countries only. In 2010, the marginal effect of improving the educational achievement by one percent to be a reduction in income inequality of 0.065 percent with the lagged Gini coefficient and 0.087 percent without the lagged Gini for a country with the average level of school attainment. This strengthens to 0.073 percent and 0.143 percent when only focused on developing countries. As for the marginal effects of the quantity of education, the equalizing

effect strengthens from 0.216 percent to 0.278 percent with the lagged Gini coefficient and from 0.319 percent to 0.409 percent for every one percent increase in the average years of school attainment. With or without the interaction of the quality and quantity of education, the marginal effects are stronger in developing countries relative to the full sample.

The direct marginal effects of the control variables are as expected. Overall openness is statistically not significantly different than zero. The coefficient on high-technological exports is positive and marginally significant. This means a country that exports relatively more high-technological products experiences higher inequality, all else equal. The corruption variable show countries with more corruption has more income inequality. Public expenditures on education as a share of GDP has a direct, negative effect on inequality overall and is statistically significant when the quality of education is included. The most important result, however, for the purposes this paper, is the consistency of the marginal effects for both quality and quantity of education. The direct effects as well as the interaction remain of the same sign and are significant. In each case, the effects of education are strengthened relative to the base line case.

Using each of the control variables, the marginal effect of the quantity of education is stronger than that of the quality of education. In other words, increasing educational attainment has a more equalizing effect for the average country compared to improving average test scores. Also interesting from Table 5 is how the marginal effects of education become stronger with the inclusion of the control variables in nearly each of the cases. The importance of education is robust to other driving factors of income inequality.

A further robustness check is to consider other measurements for the quantity of education. Above, the average years of education is the measure for the quantity of education. However, this value may be skewed based on cross-country differences in grade repetition rates. If certain countries have higher repetition rates, the average years of education may overestimate actual school attainment. To address this issue, completion rates are used as the quantity of education. Table 6 presents the results using the share of the population over twenty-five years old who (1) attained or completed primary education; (2) attained or completed lower secondary education; (3) attained or completed upper secondary education; or (4) attained or completed post-secondary non-tertiary education. These statistics are from the UNESCO Institute for Statistics and are used as the quantity of education. The results presented in Table 6 are shown without the lagged Gini coefficient for clarity.

Table 6 considers different measurements for the quantity of education, specifically the completion rates for primary, lower secondary, upper secondary and post-secondary education. In each of the cases the marginal effect of the quality of education based the 2010 average of the completion rate is negative and ranges from -0.680 (using lower secondary) to -0.835 (using upper secondary) which means the quality of education has a stronger equalizing effect on inequality when completion rates are used. The marginal effects of the completion rates are also negative when using the 2010 average quality of education. The values, in this case, are lesser in magnitude, ranging from -0.014 (using post-secondary) to -0.618 (using lower secondary). The results confirm significant interactive effects between the quality and quantity of education, but show differences when using different levels of education. The number of observations drop considerably using completion rates and there are significant differences in the results using lower levels of completion rates compared to upper levels of completion rates but greater levels of the quality or quantity of education

Table 6: Results using Completion Rates, All Countries

	(1)	(2)	(3)	(4)
Constant	-10.331** (-2.36)	-3.395 (-1.28)	2.436 (1.38)	10.575*** (3.66)
GDPpc	1.022*** (3.90)	0.846*** (3.48)	1.081*** (4.44)	0.645** (2.10)
$GDPpc^2$	-0.052*** (-3.66)	-0.044*** (-3.33)	-0.056*** (-4.29)	-0.034** (-2.04
SCORE	2.872** (2.15)	1.064 (1.32)	-0.936* (-1.67)	-2.596*** (-3.91)
Primary	2.829*** (2.60)			
Lower Sec.		1.391* (1.95)		
Upper Sec.			-0.189 (-0.36)	
Post Sec.				-2.337*** (-2.72)
Interaction	-0.859*** (-2.80)	-0.433** (-2.22)	0.021 (0.15)	0.598*** (2.68)
Observations	97	106	116	90
R-squared	0.602	0.616	0.589	0.492

Table 6: *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level. The dependent variable is the Gini coefficient obtained from the World Bank.

have a robust equalizing effect.

3 Concluding Remarks

Persistently high and, in many cases, increasing income inequality is a defining characteristic of many developed and developing countries. To understand the dynamics of inequality, attention focuses on many factors including globalization, technological change and institutional quality. One important factor is the educational system of the country, which is the focus of this paper. The quantity of education, as measured by the average years of school attainment, is commonly used in both the growth literature but also the income inequality literature. Accounting for the quality of education is inherently difficult to measure. This paper finds that both the educational attainment and the educational achievement, measured by the average adjusted test scores, to be important determinants of income inequality. Increases in both the quality or quantity of education is associated with statistically significant lower income inequality.

Moreover, the two components of education are linked together. The marginal effect of

improvements in educational achievement is dependent on quantity of education and vice versa. For the average country, greater achievement or more attainment in education lowers inequality, but the magnitude is greater for educational attainment. This is a different result when compared to economic growth, where the literature suggests the quality may have a stronger effect relative to the quantity of education. In terms of inequality, increases the educational achievement may actually serve to increase income inequality in countries with a very low level of educational attainment. In 2010, 44 of 140 countries in the sample were below this threshold.

The results are strengthened when focused solely on developing countries and are robust to the inclusion of control variables that capture globalization, technological change and institutional quality. A challenge with this research focus is measuring the quality of education using the World Bank's adjusted average test score. Additional data in terms of country coverage and time period coverage would enhance and further this research. Further investigation into the differences between primary, lower secondary, upper secondary and post-secondary completion rates as a measure of the quantity of education is an avenue of future research. It is clear, however, in terms of economic growth and income inequality, both the quality and quantity of education, and their interactive effects, are important factors.

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